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ISLAND EXTINCTIONS: THE CASE OF THE ENDANGERED NIGHTINGALE REED-WARBLER

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Abstract.—Current status of Nightingale Reed-Warblers (*Acrocephalus luscinia*) in the Mariana Islands was examined by field surveys and responses to tape recordings of calls. Historic status was determined using the literature, museum specimens, and field notes of previous researchers. Reed-warblers, historically found on five of the Mariana Islands, currently are thought to be extinct on Guam, Aguijan, and Pagan. Substantial numbers still remain on Saipan and Alamagan. Reasons for extinctions may include loss of wetlands and understory vegetation by volcanic activity, land development, and feral ungulates; fires in wetlands; pesticides; and predation by brown tree snakes (*Boiga irregularis*). *Received 25 Feb. 1991, accepted 1 July 1991.*

During the past 400 years, bird extinctions rarely have occurred in continental areas; of the 217 species or races that have disappeared, all but 17 are insular forms (Halliday 1978). In the Hawaiian Islands alone, more bird species are threatened or endangered than in the entire continental United States (USFWS 1987). Sixteen of twenty native land and freshwater bird species in the Mariana Islands are listed by federal or local governments as threatened or endangered on at least one island. The 15 Mariana Islands form an 812-km long, north–south oriented archipelago, with a total land area of 1018 km^2 (Fig. 1). All are high tropical islands, and several are still actively volcanic.

The Nightingale Reed-Warbler (*Acrocephalus luscinia*) is listed as federally endangered in the Mariana Islands by the U.S. Fish and Wildlife Service (USFWS 1970). The specific and subspecific taxonomic designations of the Nightingale Reed-Warbler have varied among researchers. Some authors have included populations from the Mariana Islands, Caroline Islands, and Nauru within *A. luscinia* (Baker 1951, Mayr 1978). Others considered the species restricted to the Marianas (Oustalet 1896, Pratt et al. 1987) or, most commonly since 1940, to both the Marianas and Carolines (Yamashina 1942, Pyle and Engbring 1985). For the purposes of this paper, we consider *A. luscinia* to be endemic to the Mariana Islands. Subspecific designations also remain in question. All recent authors consider the Pagan (*A. l. yamashinae*) and Aguijan (*A. l. nijoi*) populations to be single-island endemics. Yamashina (1942) considered the Guam population to be endemic (*A. l. luscinia*) and the other popu-

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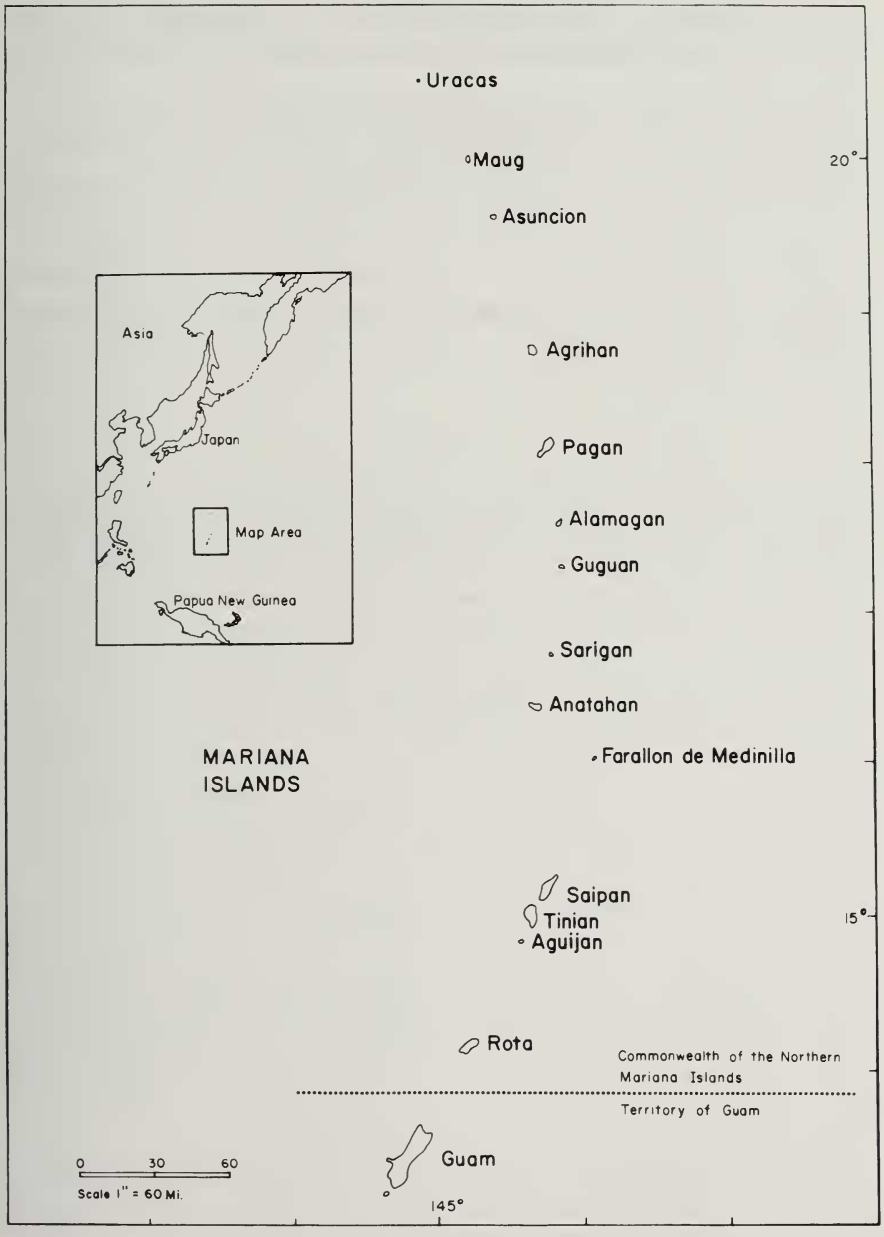

FIG. 1. Map of the Mariana Islands.

lations (Saipan and Alamagan) to belong to *A. l. hawae*; Baker (1951) felt populations from Guam, Saipan, and Alamagan should all be considered *A. l. luscinia.*

Bird surveys of the southern islands were conducted on Guam in 1981 (Engbring and Ramsey 1984) and Saipan, Tinian, Aguijan, and Rota in 1982 (Engbring et al. 1986). The Nightingale Reed-Warbler was extinct by 1981 on Guam, while it was found to be common on Saipan and rare on Aguijan. Pagan and Alamagan populations were known only from specimens collected prior to 1945; no estimates of population sizes were available. In this paper we examine the current status and historical changes in Nightingale Reed-Warbler populations on each island and relate these changes to habitat availability and usage.

METHODS

To determine historical populations of this species we (1) examined accounts in the literature; (2) wrote museums for lists of specimens; and (3) examined field notes of previous researchers in the Marianas, including those in the Guam Division of Aquatic and Wildlife Resources (GDAWR) and Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife (CNMI-DFW). POG and JDR spent three years working on Saipan for the CNMI-DFW, while GJW spent seven years working on Guam for the GDAWR. Current status on other islands was evaluated by surveys conducted on Aguijan (12 trips, 75 man-days), Alamagan (one trip, nine man-days), and Pagan (six trips, 29 man-days). These surveys included audio tape play-back to locate birds and to determine territorial boundaries, and simple watching/listening for birds by biologists familiar with, and looking/listening for, reed-warblers. On Aguijan, calls were played at least once since 1986 over the entire island (720 ha), at distances no more than 300 m apart, and additional times in areas where reed-warblers were observed from 1981–1985. On Alamagan (1130 ha), calls were played at 20–40-m intervals for 2 km up a major gully to determine approximate territory boundaries and size. The territory size was extrapolated to similar habitat throughout the island to estimate the number of pairs present. The remainder of the island was traversed in conjunction with other wildlife surveys. On Pagan (4830 ha), we played tapes at 100-m intervals over both wetland areas; additionally, about a third of the non-wetland area was surveyed with tape-playbacks performed at 300-m intervals. Approximately two-thirds of the island was covered one or more times during general wildlife surveys by people who were familiar with reed-warbler vocalizations. All Mariana Islands (except Medinilla) where reed-warblers were not historically known were visited at least three times during 1978–1989; no reed-warblers were found and no additional information on these islands is presented.

RESULTS AND DISCUSSION

Guam.—Historic accounts indicate that Nightingale Reed-Warblers were generally restricted to freshwater and brackish wetlands and river basins located on the west-central side of the island. Birds are known to have occurred at the Agana Swamp, the Atantano River marsh in Santa Rita, a low lying area near the mouth of the Masso River in Piti, and an undescribed site in Agat (Safford 1905, Bryan 1936, Stophlet 1946, Baker

1948, 1951, Kibler 1950, GDAWR, unpubl. data). A. Marche also collected birds from a presently unknown site called Snajahan (Oustalet 1895).

Reed-warblers inhabited thick cane stands and adjacent shrubbery and small trees at these localities (Seale 1901, Safford 1905, Stophlet 1946, Kibler 1950, Baker 1951, GDAWR, unpubl. data). The type of cane referred to by many authors was probably *Phragmites karka,* a tall reed that has predominated at many of Guam's wetlands for at least the last century (Safford 1905, Fosberg 1960). Reed-warblers were also known to have occurred in groves of the small introduced tree, tangantangan (*Leucaena leucocephala*) (Hartin 1961); King (1962) observed birds on a brushy hillside far from any wetland.

The type specimen of *A. luscinia* was collected by Quoy and Gaimard (1830 in Baker 1951) during their visit to Guam in 1828. Subsequent observers provided conflicting assessments of reed-warbler abundance, perhaps because of the species' limited distribution and secretive habits (Baker 1951). They were described as rare or scarce by Seale (1901), Bryan (1936), Stophlet (1946), Kibler (1950), and Mayr (1945). However, Safford (1902) claimed that they were "not rare" in the Agana Swamp. Baker (1951) and his collecting team also found *A. luscinia* to be fairly common at some locations, particularly in the Agana Swamp.

In 1960, Hartin (1961) reported Nightingale Reed-Warblers to be fairly common, and King (1962) saw several during a three-day visit to the island. A few reed-warblers remained in the Atantano River marsh until early 1968 (J. Jeffrey, pers. comm.). The birds were still fairly common in parts of the Agana Swamp in 1967 or 1968 (J. Jeffrey, pers. comm.) but then rapidly disappeared. The last known sighting of a reed-warbler on Guam occurred there in 1969 (GDAWR, unpubl. data). Numerous searches of all Guam wetlands since 1970 have not detected reed-warblers (Pratt et al. 1979; Ralph and Sakai 1979; Tenorio and Associates 1979; Jenkins 1983; Engbring and Ramsey 1984; GDAWR, unpubl. data).

The reed-warbler's limited habitat distribution probably made it vulnerable to disturbances of wetlands. Rice and taro were grown in several of the island's wetlands from the 1800s until World War II (Seale 1901, Safford 1905, Thompson 1947, Baker 1951). These agricultural activities resulted in the draining and cutting of sizable areas of reed beds and probably reduced reed-warbler numbers (Seale 1901). Wetland cultivation of crops declined after World War II, allowing a resurgence of natural marsh vegetation at many locations (Baker 1951, Solenberger 1967).

There is little evidence that habitat loss caused the final decline of reed-warblers on Guam (GDAWR, unpubl. data), despite recent suggestions (Jenkins 1983, Engbring and Ramsey 1984). Some filling of wetlands

occurred in the 1960s and 1970s, especially in the Agana Swamp, but luxuriant stands of *Phragmites,* ranging from 1–70 ha, continue to persist on the island to the present (Stinson et al. 1991).

Baker (1951) believed that dry season marsh fires were potentially harmful to Nightingale Reed-Warblers at some sites. Several fires burned through large portions of the Agana Swamp in the 1960s (G. S. A. Perez, pers. comm.) and may have adversely affected reed-warbler numbers in the marsh.

Drahos (unpubl. data) contended that pesticide use was a more likely cause of the reed-warbler decline but had no direct evidence of this. After World War II, DDT was applied liberally for insect control on Guam, Saipan, and Micronesian islands occupied by the military (Baker 1946). The U.S. Navy also conducted a spraying program on Guam in the late 1950s and 1960s to combat the threat of mosquito-borne diseases such as malaria and dengue (GDAWR, unpubl. data). It is likely that wetlands were targeted in these control programs in an effort to reduce mosquito numbers. Tests conducted in 1981 indicated that pesticide levels on Guam were low and probably not responsible for the current declines of Guam forest birds (Grue 1985). However, pesticides cannot be ruled out as a cause for the earlier reed-warbler extinction.

We speculate here that predation by brown tree snakes (*Boiga irregularis*) may have played a key role in the final disappearance of Nightingale Reed-Warblers on Guam, as it did in the extinction of native bird species in forest habitats on the island (Savidge 1987, Engbring and Fritts 1988). Baker (1951) felt reed-warblers had never been abundant on Guam and that lack of predators, especially snakes, may have allowed them to survive in low numbers through the 1940s. Tree snakes were introduced to Guam after World War II and first appeared in south-central Guam in the 1950s in the vicinity of the U.S. Naval Magazine, which is only 3–5 km from several of the swamps formerly used by reed-warblers. The snake population gradually increased and radiated outward into southern and central Guam by the late 1960s and early 1970s (Savidge 1987). This spread coincides with the decline of reed-warblers. Tree snakes are generally thought to avoid marshes, although there have been rare sightings in this habitat. However, snakes almost certainly forage in shrubs and trees next to reedy wetlands. The reed-warbler's use of shrubby edge vegetation at swamps may have made it more vulnerable to snake predation than biologists have previously believed.

Aguijan.—The only pre-1945 evidence of reed-warblers are five specimens taken by a Japanese collector on 29 February 1940, all currently in the Yamashina Institute for Ornithology (K. Momose and T. Hiraoka, pers. comm.). This small collection indicates that the bird was more

common prior to World War II than by the time of the intensive surveys conducted in the early and mid-1980s. G. D. Peterson (unpubl. data) found Nightingale Reed-Warblers to be one of the least common forest birds in 1954 on Aguijan, while an intensive U.S. Fish and Wildlife Service forest bird survey in 1982 (Engbring et al. 1986) estimated the population at 4–15. A maximum of six birds was recorded on one of the four trips by CNMI-DFW personnel during 1983–1985 (30 man-days), and the last sighting occurred in July 1985 (D. Aldan, pers. comm.). None was found during 1987–1990 on eight trips by JDR, POG and other CNMI-DFW personnel (45 man-days). It seems likely that the endemic subspecies (*A. l. nijoi*) on Aguijan is extinct.

Under the Japanese administration (1914–1945), Aguijan was heavily farmed, resulting in extensive clearing and modification of the vegetation. Goats, feral on the island since at least the early 1950s, have destroyed most of the forest understory, preventing many tree species from regenerating. No wetlands occur on Aguijan; reed-warblers were apparently restricted to native forest areas, particularly those areas with dense canopy cover (Engbring et al. 1986; CNMI-DFW, unpubl. data). The extreme habitat changes during the past several decades, coupled with small island size, were likely responsible for the extinction of the bird on this island.

Saipan.—The Nightingale Reed-Warbler was first reported from Saipan by Hartert (1898). Additional collecting took place under the Japanese administration when collectors obtained 22 specimens during three periods totaling about 60 days in 1931–1932; 10 are currently in the Yamashina Institute (K. Momose and T. Hiraoka, pers. comm.). During the Japanese period, much of the Lake Susupi area and more than 50% of Saipan was used for agriculture (USACOE 1986). Reports immediately following World War II indicate a small population of reed-warblers was present and probably restricted to wetland areas (Stott 1947, Marshall 1949).

More recently we have found Nightingale Reed-Warblers common over much of the island in both wetland and upland habitats. Ralph and Sakai (1979) estimated there were 45/km^2 in a 7.3-h census. This number is similar to the 46/km^2 found in a much more intensive survey of the entire island with 488 eight-min counts in 1982 (Engbring et al. 1986). Much land has been cleared over the past decade, and this development is continuing at an accelerating pace. This will certainly reduce the population in the near future.

Nightingale Reed-Warblers on Saipan currently use a wide variety of habitats ranging from *Phragmites* wetlands to tangantangan stands and native limestone forest (rarely). We have found them most commonly at wetland/upland ecotones and in mixed tangantangan/grassland habitats,

as did R. Craig (pers. comm.). These are both characterized by dense understory. The current population is certainly high compared to that found following World War II and is likely higher than early periods. This may be due to one or more of the following factors: (1) increased edge habitat from fragmentation in recent decades; (2) replacement of large tracts of native forest with tangantangan forest; and/or (3) adaptation of Nightingale Reed-Warblers to new habitat types.

Alamagan.—H. Orii of the Yamashina Institute collected five specimens on 18 February 1931 (K. Momose and T. Hiraoka, pers. comm.), the only record of this species prior to our survey in 1988 (nine man-days). We played taped songs to survey this species on the south side of the island. During intensive surveying up a typical long wooded gully, we found territories at 60–100 m intervals. Birds were seen in habitats with a partially open overstory and somewhat brushy understory; they also were seen in dense swordgrass (*Miscanthus floridulus*), but only within about 50 m of an ecotone. Birds were not seen in the denser forests at elevations over 300 m. Based on the amount of suitable habitat and territory size, we calculated a population of at least 100 pairs on the south side of the island. We did not get to the north side of the island; however, a 1990 survey by other CNMI-DFW personnel confirmed that reed-warblers were also common there (C. Rice, pers. comm.). Our estimate for the Alamagan population is conservatively 350 pairs; actual numbers could range to a maximum of 1000 pairs.

Feral goats, pigs, and cattle have drastically changed the vegetation of Alamagan since their arrival in the mid-1700s (S. Russell, pers. comm.). At lower elevations, the forested gullies have the only remnant native vegetation, primarily trees. The understory is largely composed of introduced species. The ground vegetation (except swordgrass areas) is sparse, reminiscent of desert badlands with open spaces between individual plants (perhaps 50% ground cover). At all elevations, the ridges and most slopes are covered by tall, thick swordgrass. Vegetation and erosional patterns are characteristic of islands with a long history of overgrazing by feral ungulates.

Pagan.—Little information is available on the population of Nightingale Reed-Warblers from Pagan except specimen collections by Marche (10 in 1887) (Marche 1889; Oustalet 1895; C. Jouanin, pers. comm.) and Orii (19 in 1931) (K. Momose and T. Hiraoka, pers. comm.) that indicate it may have been locally common in wetlands. D. Aldan and J. Sablan, two former residents of the island, report the last reed-warblers were present until at least the 1960s but occurred only in the wetlands near the upper, or possibly both, of the island's lakes. Despite intensive searching in the vicinity of both lakes, we (and other CNMI-DFW personnel)

failed to find reed-warblers during six trips to Pagan (29 man-days) in 1983–1989 nor did other researchers in the late 1970s (Tenorio and Associates 1979; R. Clapp, pers. comm.). It seems probable that the endemic subspecies (*A. l. yamashinae*) on Pagan is extinct.

Wetland habitat has been drastically altered and reduced on Pagan during the last century. Major causes include 1914–1945 Japanese development; feral goats, pigs, and cattle; and a 1981 and later volcanic eruptions (Marche 1889, Corwin et al. 1957, Tenorio and Associates 1979). By 1979, there was little shoreline vegetation at either lake (Tenorio and Associates 1979). The 1981 and following eruptions eliminated all herbaceous and most woody vegetation in the upper lake area which is only now (1989) beginning to make a comeback. There is currently less than a 1% vegetative ground cover bordering both lakes and no emergent vegetation in either.

Habitat and extinction.—The Nightingale Reed-Warbler has become extinct on islands where it was primarily restricted to wetlands (Guam and Pagan). This is not surprising, given the fate of the other three wetland bird species native to the Marianas. The Marianas Mallard (*Anas platyrhynchos oustaleti*) and White-browed Crake (*Poliolimnas cinereus*) are both extinct (Jenkins 1983, Reichel and Glass 1991). The Marianas Common Moorhen (*Gallinula chloropus guami*) is endangered throughout the Marianas and extinct on Pagan and Rota (Becker and Butler 1988, Stinson et al. 1991). Vegetated wetland habitat has been essentially eliminated on Pagan, the decline taking place over at least 60 years. Moderate losses have occurred on Guam, but the area lost has never been quantified. Fires and cultivation in wetland areas at times may also have contributed to reed-warbler declines.

On Guam, habitat loss probably did not cause the final decline of the reed-warbler. Brown tree snakes may have played a key role in the final extinction of the reed-warbler, as they have in the declines of other native birds (Savidge 1987, Engbring and Fritts 1988).

The cause of extinction on Aguijan is less clear cut. We agree with Engbring et al. (1986) that the rarity (and now probable extinction) of reed-warblers on Aguijan may be the result of habitat destruction by feral goats. However, this has certainly not been the case on Alamagan where perhaps the densest population of reed-warblers still exists despite the fact that Alamagan is severely impacted by feral animals. The difference may be explained in the density of understory vegetation and amount of grassland, which, though not quantified, may be an order of magnitude greater on Alamagan.

It seems likely, given the known historic distribution of reed-warblers in the Marianas, that local extinctions are not uncommon. Nightingale

Reed-Warblers are known from only five of the southern ten islands (Fig. 1). Their distribution seems unrelated to local bird species diversity, habitat, or island area patterns. This patchy distribution is typical of the relictual pattern of a formerly widely distributed species and is typical of many bird species (including *Acrocephalus*) in both Micronesia and Polynesia (Pratt et al. 1987, Steadman 1989).

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